STRESS EVOLUTION AND NANOMORPHOLOGY DURING THIN FILM DEPOSITION - IN SITU NANOMECHANICS

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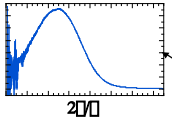
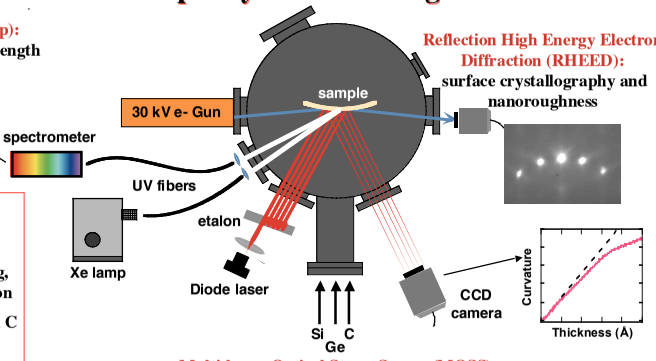
Group IV Molecular Beam Epitaxy + In Situ Diagnostics

Light Scattering Spectroscopy (LiSSp):
surface spatial period and correlation length





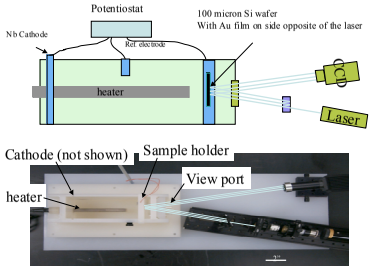
Reflection High Energy Electron Diffraction (RHEED):
surface crystallography and nanoroughness

Additional experimental capabilities:

- Atomic hydrogen source
- Kaufman ion source for high rate etching, sputter deposition, and energetic deposition
- Negative ion deposition source for Si and C
- Atomic force microscopy
- Gas ambient annealing

Multi-beam Optical Stress Sensor (MOSS):
substrate curvature measurement for sensitive real-time stress evolution

Electrodeposition + In Situ Diagnostics

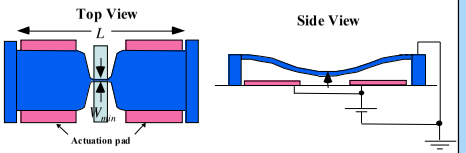


System Capabilities:

- MOSS measurements during electrodeposition
- Three and four point probe electrochemical measurements

TEM studies of Nano-mechanical deformation processes

Quantitative stress-strain measurements *in-situ* of a TEM



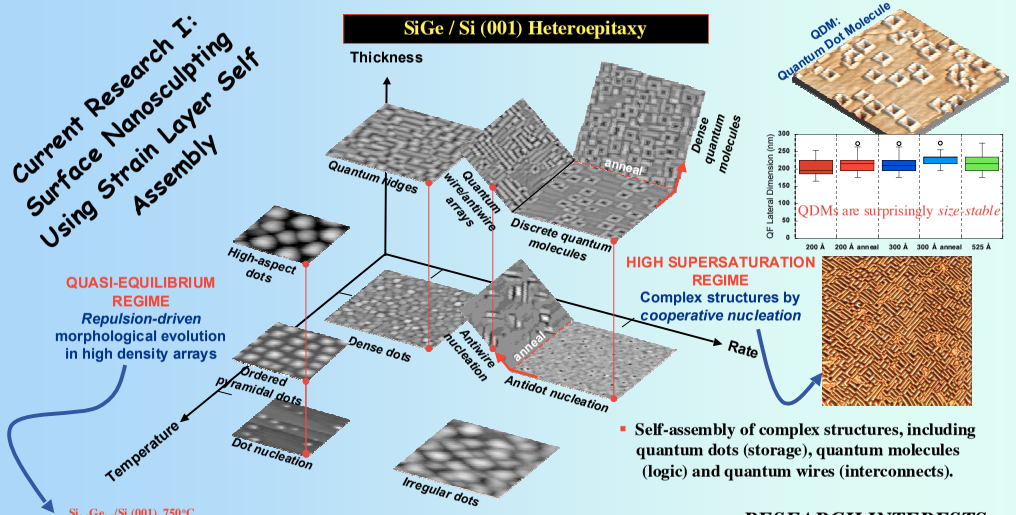
MEMS-based tensile tester designed for actuation *in-situ* in a TEM.

Gauge section located over Bosch hole through the wafer to facilitate plan-view TEM imaging during actuation.

Collaborator: M. De Boer

Current Research I: Surface Nanosculpting Using Strain Layer Self Assembly

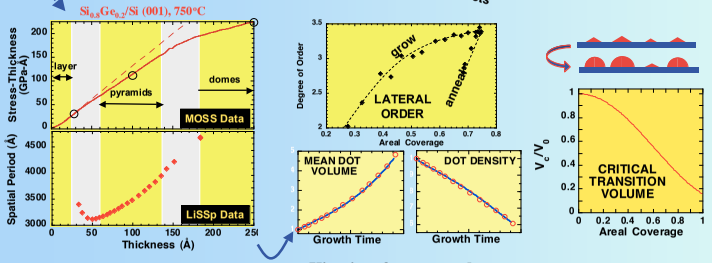
SiGe / Si (001) Heteroepitaxy



QUASI-EQUILIBRIUM REGIME
Repulsion-driven morphological evolution in high density arrays

HIGH SUPERSATURATION REGIME
Complex structures by *cooperative nucleation*

- Self-assembly of complex structures, including quantum dots (storage), quantum molecules (logic) and quantum wires (interconnects).



- Transition identification, elastic relaxation and length scaling
- Kinetics of quantum dot ordering and coarsening
- Energetics of quantum dot phase transitions

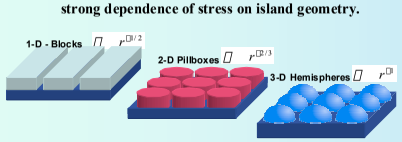
RESEARCH INTERESTS

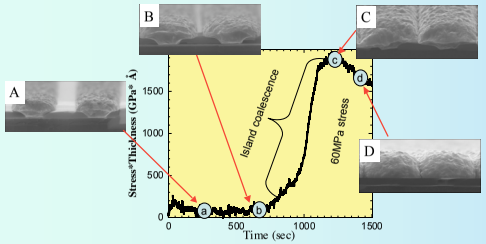
- Strain-layer heteroepitaxy
- Self assembly of quantum nanostructures
- Strain relaxation mechanisms
- SiGeC alloys
- Effects of hydrogen on growth kinetics
- Energetic deposition
- Amorphous SiGe

Electrodeposition allows for unique studies of the effect of restricted geometries (via selective area growth) on stress and microstructure

Island Coalescence

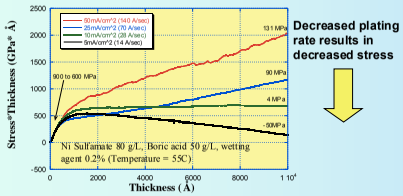
Hertzian contact model for island coalescence predicts a strong dependence of stress on island geometry.





Unpatterned films

Build upon studies of discrete phenomena to understand stress evolution in blanket films.



Decreased plating rate results in decreased stress

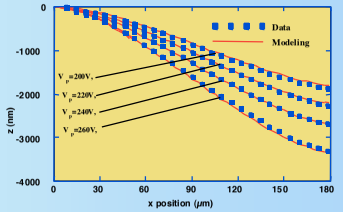
Analysis technique

Ex-situ interferometry is used to characterize the stress-strain response of the MEMS structures.

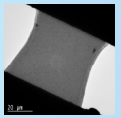
Unloaded

Loaded

Stress-strain response determined from finite element analysis of data



Deflection data for poly-Si beam



TEM micrographs of unloaded Al beam in actual structure

Developing capability to build device using both lift-off masks and electroplating to allow study of nano-structured Al, Ni, and Cu.